

LAND COMBAT SYSTEMS INDUSTRY REPORT

Academic Year 2002 - 2003

ABSTRACT: The United States remains the preeminent power in the global land combat systems (LCS) industry. The single most significant event in the LCS industry is the U.S. Army's transformation to the "Objective Force," a lighter, more agile and deployable, more lethal force. The premier program of this transformation, the Army's Future Combat System (FCS), will be expensive, absorbing the majority of the Army's near-term research and development (R&D) funding, as well as the procurement and operations and maintenance funds previously earmarked for upgrades to existing weapons systems. The selection of a "lead systems integrator" to coordinate and integrate the fielding of a "system of systems" capability has itself greatly changed the industry, but has also generated some concerns. Overall, demand for land combat vehicles has declined, and funding levels have consequently decreased as well. While some of the land combat manufacturing firms have diverse product lines and can weather the vagaries of the defense business, others are entirely devoted to defense products and their continued viability remains uncertain.

LTC(P) Michael E. Donovan, USA

Lt Col Dale S. Gabriel, USAF

LTC(P) Timothy G. Goddette, USA

Col Andrew Haeuptle, USMC

Col Raul Heredia, Philippine Army

Mrs Gwendolyn Jaffe, U.S. General Accounting Office

Mr Thomas Julian, Office of the Secretary of Defense

LTC Winston E. Lewis, USA

Col Jeffrey Mayo, USAF

Lt Col James C. Moulton, USAF

LtCol Michael J. Mulligan, USMC

Mr Daniel Pierson, Defense Advanced Research Projects Agency

Lt Col Hans-Peter Walser, Swiss Army

LTC(P) John A. Wilhelm, USA

Lt Col Brian Yolitz, USAF

Professor Donald Briggs, Faculty Lead

COL Peter Fuller, USA, Faculty

Col Michael Schmitt, USMC, Faculty

Dr Roger Channing, COL, USA (Ret), Faculty

Professor Paul Severance, COL, USA (Ret), Faculty

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PLACES VISITED/INDUSTRY SPEAKERS:

Domestic:

AAAV Program Office, Woodbridge, VA
Aberdeen Proving Ground, Aberdeen, MD
Boeing-SAIC, Lead Systems Integrator, Future Combat Systems
Oshkosh Truck Company, Oshkosh, WI
United Defense, York, PA
AM General, Mishawaka, IN
Stewart & Stevenson Tactical Vehicle Systems, Sealy, TX
Battlespace Integration Center, Fort Hood, TX
Lima Tank Plant, Lima, OH
General Dynamics-Canada, London, Ontario, Canada
General Dynamics Eagle Enterprises (Robotics)
General Dynamics Land Systems, Warren, MI
U.S. Army Tank-Automotive and Armaments Command, Warren, MI
Detroit Diesel Corporation, Detroit, MI

International:

Steyr-Daimler-Puch Spezialfahrzeug AG, Vienna, Austria
Krauss-Maffei-Wegmann, Munich, Germany
Mowag Motorwagenfabrik AG (General Dynamics), Kreuzlingen, Switzerland
GIAT Industries, Versailles, France
Alvis Vickers Limited, Newcastle-upon-Tyne, United Kingdom

INTRODUCTION: In order to assess the health of the domestic and international land combat systems industries, the study team visited several U.S. government facilities and American and European industrial manufacturing firms. Each team member conducted research and wrote an individual paper, some of which are included in this report in condensed form.

Over the past few years several factors have dramatically affected the LCS industry: post-Cold War military budget decreases; the emergence of the U.S. as a lone superpower; globalization; and the changing perspectives of major military and commercial organizations and leaders.

First, the end of the Cold War brought with it the so-called “Peace Dividend,” which included sharp reductions in military budgets and declining worldwide expenditures on land-oriented weapons systems. Former Secretary of Defense Perry in 1993 correctly predicted that the number of U.S. prime contractors must necessarily decline either through attrition or consolidation. The results of this movement are mixed. While low overhead costs, just-in-time inventories, and improved processes have proven fairly successful, new concerns about the industry’s change have emerged. Among these concerns are the abilities of the new leaner firms for surge production, and how much consolidation can occur and still allow competition.

The post-Cold War era also fostered a new focus with regards to the nature of conflict and the Department of Defense’s (DoD) ability to respond. The 20th century ended with the United States firmly established as the world’s lone superpower. Further, the conclusion of the U.S.-Soviet bilateral standoff ushered in a new era of regional, ethnic, and religious conflict. The Balkans, Somalia, East Timor, Rwanda, and others all served as examples of the “new” world disorder. This led DoD to reconsider prior concepts of the size and speed of its land combat systems. The shift to a more rapidly responsive all-purpose force required an examination of capability shortfalls: transportability, sustainability, and maintainability in remote, austere environments.

The manufacturing industry has traditionally become involved in the acquisition of weapons systems only after the military has specified its requirements and requested proposals from industry (known as “requirements pull”). Industry’s input into this complex transformation is vital, yet it remains to be seen whether the commercial firms will demonstrate initiative in helping to shape the transformation through its vision of what may be possible (“technology push”), or will remain passive on the sidelines.

THE INDUSTRY DEFINED: Today, the LCS industry encompasses a wide variety of systems ranging from main battle tanks to lightweight soldier-carried weapons. The major systems include: command and control systems; the individual soldier; artillery; small arms and shoulder-mounted weapons; support vehicles; wheeled tactical vehicles; and tracked armored vehicles. This industry study focused on heavy tracked armored vehicles, lighter wheeled armored vehicles, and tactical trucks.

Further, the Army generally classifies LCS platforms in three categories:

- a) Legacy system - A legacy system is one that is currently operational, and for which there exists a mid- to long-range plan for phase-out. The M1A1 Abrams main battle tank and the M2 Bradley infantry fighting vehicle are two examples of legacy systems.
- b) Interim system - Interim systems serve as a bridge between legacy systems and objective systems, or as a future member of the Army’s Objective Force. The Stryker platform is the Army’s primary interim weapons system. The Stryker program includes a six-year, \$4 billion contract with a joint GM Defense-Canada and GDLS venture. (GDLS has since acquired GMD-Canada.) GDLS will deliver 2,121 vehicles by 2008, enough to outfit six brigades. The Stryker is the Army’s first new ground combat acquisition since the 1980 introduction of the Bradley infantry fighting vehicle.
- c) Objective Force – Future Combat Systems (FCS) is the lynchpin of the Army’s transformation game plan. By 2032, FCS is supposed to fully replace the current fleet of Abrams tanks, Bradley fighting vehicles and other armored vehicles.

CURRENT CONDITION:

U. S. Industry Trends

Following the end of the Cold War, shrinking defense budgets triggered a series of defense industry consolidations. Many suppliers left the market for other opportunities and, in some cases, went out of business entirely. The net result was a defense industry consolidation from 51 business units in 1989 down to 4 firms in 2002.^[1]

This defense-wide industrial consolidation has had a profound impact on the land combat systems industry: the past decade witnessed an inexorable shift from a much broader-based network of contractors. HARSOC/BMY and FMC-Carlyle Group combined to form United Defense; AV Technology/GDLS/Teledyne Vehicle Systems/LM/Ceridian all gradually came together to form GDLS...and most recently GDLS acquired a significant number of additional firms: a domestic robotics company, GM Defense-Canada, Switzerland's Mowag, and Spain's Santa Barbara Sistemas. The overall number of U.S. producers of tactical wheeled vehicles has decreased from six to three, and for tracked combat vehicles, the number has decreased from three to two. Additional discussion of current economic trends and current conditions is presented in the first essay later in this paper.

International Industry Trends

While most European nations have only a single manufacturer of land combat systems, the total number of European manufacturers creates extreme competition among similar vehicles. Since their own national requirements for land combat systems are alone insufficient to sustain the companies, they must look to foreign sales to stay in business. There are almost three dozen separate companies that serve a worldwide market that simply cannot sustain them in terms of production requirements or revenues.

CHALLENGES

With the drastic transformation from heavy to lightweight systems, and the possible impact of lessons learned from recent operations in Iraq, it's a fascinating time to be studying the land combat systems industry. However, the LCS industry will face a number of challenges, which are discussed here.

The FCS challenges:

- a. The “System of Systems.” One of the central tenets of the FCS concept is its “network-centric” focus. The FCS is intended to be a “system of systems” which will “...trade armor for information.” However, there is no indication that there is a real focus within the LCS industry on the command, control communications, computer systems, intelligence, surveillance and reconnaissance (C4ISR) part of the equation. Throughout our study, all of the major industry players focused on the platforms: size, tracks vs. wheels, kinetic capabilities, armor requirements, and so forth. The major industry players all talk about “what” the FCS system-of-systems should do (connect all of the players together for full information dominance and increased lethality), but there has been little discussion of “how” this will be accomplished. This is especially vital because the network-centric capability of the FCS is what distinguishes it from its predecessors.
- b. Capability Requirements. Further, there is concern whether there is an imbalance in the requirements set between the focus on all FCS systems being “C-130 transportable” and their connection to the C4ISR network. Should heavier legacy systems and the interim Stryker forces be excluded from being part of the network?
- c. Threat assessment. The Army is betting its future credibility and capability on the FCS concept. It has cancelled numerous programs and drastically cut funding on many others in order to lay the groundwork for it. However, an additional threat capabilities assessment should be validated before the Army makes such a major commitment. For example, Operation Iraqi Freedom demonstrated that there might still be a place for a heavy armored capability, especially when operating in urban

environments and against asymmetric threats. The decision to completely divest legacy capabilities from the objective force should be revisited ... survivability concerns may indicate a continued need for heavy armor on the battlefield.

- d. Risk assessment. As the Army cuts programs and culls resources from its legacy systems in order to build the objective force, it assumes some level of short- to mid-term risk in its ability to respond to a crisis. The service must ensure that this decision is validated in light of recent lessons learned from Operation Iraqi Freedom and analysis of short- to mid-term conflict possibilities. Very recently, Congressional budget additions provided support for some of the Army's legacy forces, but this kind of '11th-hour' salvation for programs cannot be counted on year after year.
- e. A "joint program." Considering the stakes involved in the FCS program, should the program graduate from a service-specific program to a joint program? There are several considerations that merit this examination. The first one is the nature of the program: its focus is a "system of systems" which is designed to integrate all capabilities in order to achieve info dominance and unprecedented lethality. Therefore, the network-centric system should incorporate other Army assets (such as artillery and special forces) and Air Force/Navy assets (for close air support and interdiction, plus significant unmanned aerial vehicle, or UAV, capabilities). Further, the USMC is embarking on its own next-generation LCS: the Marine Air-Ground Task Force (MAGTF) Expeditionary Family of Fighting Vehicles (MEFFV). The focus on systems integration, combined with the requirement to fight jointly and enhanced by the massive financial investment required to make the FCS program a reality, dictates that there be some consideration to raising it to a joint level.

Economic Challenges

Funding is the most obvious economic challenge. The Army has already, in this year alone, terminated 24 systems and cut back another 28 systems in order to fund the Stryker and FCS programs. Some of the cuts included modernization of legacy forces such as Bradley vehicles and Abrams tanks, which will remain in the inventory until as late as 2035. Depending on what technical difficulties the FCS system faces, and in the event that there is reconsideration with regards to the utility of the heavy legacy systems, these systems could remain in the inventory even longer than 2035. At some point, funding for modernization (or simply Operations and Maintenance or O&M, funding to maintain the legacy systems) will need to be considered. Reliance on Congressional additions to the Defense budget is a risky proposition.

There is excess manufacturing capacity both home and abroad. This cost will only become more painful for both government and private industry as demand for LCS systems decreases. This issue is discussed further in the essay section.

Also, an evolution is taking place with regards to procurement strategies. The previous stereotype of an LCS platform procurement plan revolved around manufacturing large numbers of a relatively standard weapons system. However, that paradigm is shifting: today, fewer and fewer numbers are involved in an initial weapons purchase. This trend is further promulgated by the increasing costs for more sophisticated, complex systems. Further, the industry should make adjustments in order to accommodate more flexible long-term/multi-year, follow-on contracts that would enhance real-world spiral development.

Cultural Challenges

- a. Industry motivation. There is in reality very little motivation for most U.S. individual industry players to really pursue innovative technological research and development. The focus of the LCS industry is to integrate proven technology (with small strides in capabilities) into platforms. Although there is plenty of discussion, there is very little real effort to pursue such concepts as hybrid-electric drives, diagnostic-power trains, and real C4ISR capability improvements. Unlike the commercial sector, some of the major defense players depend on government R&D funding.

Maintaining a credible defense industry base (both personnel and hardware), combined with the consolidation of the defense industry's players and the nature of the relationships among them, may well have sapped much of the competitive spirit within the LCS industry.

- b. Commercial-Off-the-Shelf products and “families of vehicles.” In order to decrease development costs, there is a movement toward commercial-off-the-shelf products and already-proven items. Will reliance on COTS products endanger future supportability?
- c. Mergers within the industry. Mergers and partnerships among former industry “competitors” are occurring more frequently, and are taking place on an international scale. This will have profound implications for the industry, as different national and corporate identities are thrown together
- d. Focus on follow-on training and logistic support. Previously, the industry’s focus was on initial manufacturing. However, there is a trend toward an emphasis on post-manufacturing services, such as follow-on training and long-term logistic support.

Political Challenges

The political challenges associated with transformation of the LCS industry from the legacy force to the interim and objective forces are perhaps the most daunting. As leadership changes within Congress, OSD, CJCS, and the Army, the path of military transformation is likely to change. Secretary Rumsfeld is directing major leadership changes within the Army, causing a significant effect on the transformation paradigm for the Army as a whole, and for the FCS and LCS industry in particular. Congress will have a major role in determining the future of land combat systems, despite whatever the Army and Secretary Rumsfeld have planned.

Lead System Integrator (LSI) Challenges

The LSI concept is a key part of the FCS’ development. A major tenet of the LSI concept is based on the integrator’s authority and ability to coordinate and mesh the various elements of a program (coordinating the parts of the “system of systems,” as opposed to relying on technical expertise in the particular weapons system). However, there are several significant issues, corporate knowledge and proprietary data, that must be considered.

First, there are significantly differing views within the LCS community on the efficacy of the LSI concept. Already, the present integrator (whose background is primarily in aviation) is pursuing avenues which have been questioned by the traditional “armor guys.” Further, there are differences of views with regard to private versus DoD interaction and the amount of decision authority vested in the LSI. Senior Army personnel have consistently emphasized the need for the LSI to use government personnel and expertise. Yet this debate has not been fully sorted out, leaving the fundamental question of strict separation of roles, authority, and responsibility unresolved. Further, Boeing’s LSI role brings up a number of proprietary issues. There are fundamental questions regarding what might belong to whom, an issue that could become very contentious in an era of limited defense funding.

Contractor Logistic Support Challenges

Implementation of the CLS concept in support of the FCS program will create a new gray area. The issue of contractors on the battlefield raises a host of legal, logistical, and recruiting and retention questions that have not been fully addressed. LCS contractor support on the battlefield represents a huge step in “out-sourcing” military jobs on the battlefield. While it will undoubtedly comprise part of the solution for logistics support on the battlefield, it probably doesn’t represent an absolute solution.

OUTLOOK:

New Markets and Requirements

- a. Peacekeeping/Stabilization missions. The past decade witnessed a surge in peacekeeping missions: Afghanistan, Kosovo and Bosnia, East Timor, and now Iraq. This has brought on a corresponding growth in the market for armored tactical vehicles. These vehicles will face stiff requirements for mine protection, small arms protections, and speed and mobility. In fact, peacekeeping has become a significant niche market for the European LCS industry. There is already a full host of companies in Europe that are pursuing this market, and it remains to be seen if U.S. companies will follow suit.
- b. Second-hand equipment and upgrades. Due to the decreases in many international defense budgets, there is a developing market for second-hand equipment. Many European, Middle Eastern, and Pacific nations do not have the money to invest in new, state-of-the art armored vehicles. Thus, there is a high demand for purchasing refurbished older models, and for upgrading existing legacy systems (such as the M60, T-72, and M-109).

Interoperability: the United States vs. the rest of the World.

In terms of defense research and development, funding, and concept investigation, the United States is way out in front. Every financial indicator demonstrates that defense spending in the rest of the world does not begin to approach U.S. defense spending. Further, no one else is looking at nearly as broad a spectrum as this nation. One second-order effect of these developments is the probability that the gap in operational capabilities between the U.S. and its allies will continue to grow. This factor will undoubtedly affect future coalition operations.

From these factors we believe the U.S. land combat systems industry will remain preeminent, and will actually widen the technological gap currently existing between American and European capabilities. Despite considerable consolidation, the U.S. LCS industry stands ready to support national security objectives. We note from observation and discussion during our industry visits that despite current excess manufacturing capacity, the ability to rapidly surge production (an unlikely event in itself) is highly doubtful.

GOVERNMENT: GOALS AND ROLE:

The U.S. government's role is easy to state, but much harder to enforce: field the most effective combat capability for its defense dollars! Some of the factors that will continue to consume government attention and concern include:

- a. Sustaining a capable technological industrial base. One of the effects of globalization is that the LCS is not a "home-team" venture. Many weapons systems' components, subsystems come from international corporations. While this approach makes pure economic sense, it raises several questions: first, what are the risks associated with fielding, sustaining, and upgrading international platforms; secondly, at what level should the U.S. sustain the core of engineers, scientists, and metal-benders, if at all?
- b. Balancing the costs and risks associated with R&D for LCS concepts. Different corporations throughout Europe have met with varying degrees of success across the spectrum of government-private industry research and development. This nation must continue to weigh the pros and cons of both approaches, and adopt plans that allow for some degree of individual risk-taking (in areas such as robotics or hybrid drives) without allowing private industry to simply sit back and reap the benefits of government-sponsored R&D.
- c. Ensuring sufficient competition. There are two schools of thought. One opinion is to let the market forces take their natural course and do not be concerned with who survives the effects of the "funding bathtub." Competition is not a major concern in the traditional sense under this option. Yet it fails to consider consequences for the defense industrial base. The other opinion is to split work among the surviving competitors to help navigate the political landscape and maintain congressional and OSD support in the future, as well sustaining the LCS industrial base. The

strategy being deployed seems to split the work almost 50/50 between the two traditional heavy armored vehicle firms under the LSI for both the R&D and production. This may have been done for political reasons once the legacy upgrades and other programs were cut dramatically to pay for FCS.

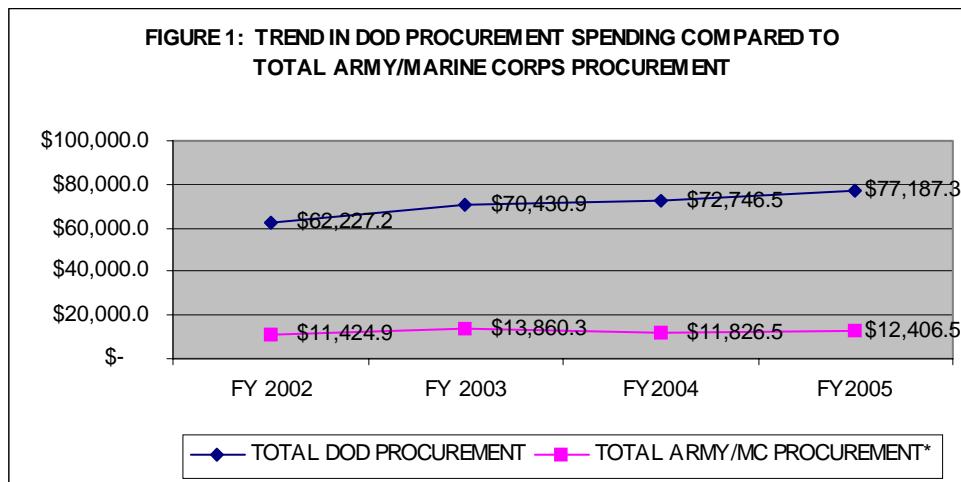
ESSAYS ON MAJOR ISSUES:

The following essays provide additional discussion on some of the major issues introduced previously in this paper.

Economic Outlook

Given the increased emphasis on modernization, and widely publicized increases in defense spending, one might expect to see land combat system procurement budgets to at least keep pace with increases in defense spending. This is not the case. If one examines DoD's FY 2004-2005 budgets for tracked and tactical combat vehicles, the following trends emerge:

- a) First, DoD's ground forces will not maintain their share of defense procurement budgets out to FY 2005. The combined Army and Marine Corps share of the defense procurement pie shrinks from 18 percent to 16 percent from FY 2002 to FY 2005. The divergence between the blue and purple lines in Figure 1 indicates that combined Army and Marine Corps procurement spending will not keep pace with DoD's, even though, in absolute dollar terms, Army/Marine Corps procurement dollars actually increase over this period from \$11.4 billion to \$12.4 billion (though due to inflation these dollars won't buy as much then as they do now).



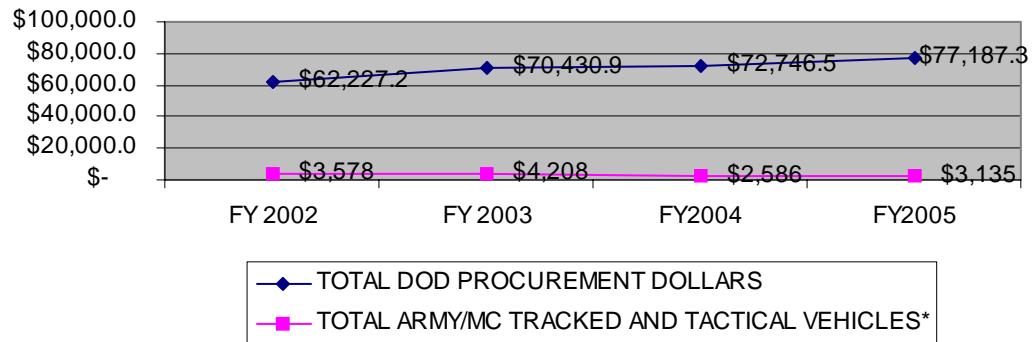
i. Dollars in millions.

ii. Source: Data extracted from the Department of Defense Budget for FY 2004-2005 (Procurement Programs-“P-1”)

So, as a starting point in this analysis, the land combat systems industry won't see large near term increases in combined Army and Marine Corps procurement budgets—and both services have needs beyond just combat vehicles.

- b) Second, spending on the Army's “legacy” land combat systems will take a major hit as DoD leadership decides to take “operational risk” in the near term to ensure transformation occurs in the longer term. To see how this looks in the FY 2002 to FY 2005 time period, consider the following trend lines in Figure 2:

FIGURE 2: SPENDING ON TRACKED AND COMBAT VEHICLES DECLINES

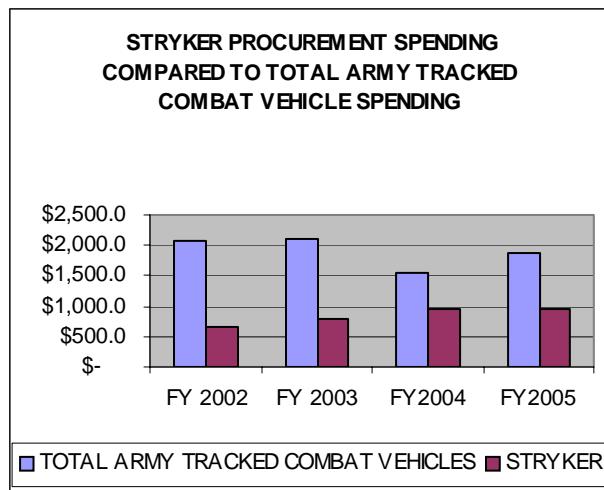


Dollars in millions.

Source: Data extracted from the Department of Defense Budget for FY 2004-2005 (Procurement Programs-“P-1”)

What does this mean to the land combat systems industry? In the near term, dollars being budgeted for Army and Marine Corps tracked and tactical vehicle programs will actually decline, despite the much advertised growth in defense spending. Even more dramatic is the shrinking of Land Combat System of Total DoD procurement dollars—from six percent down to four percent. This does not bode well for companies that do not have a lock on existing procurement programs. However, this is consistent with DoD's decision to forego procurement spending on some legacy systems, to pave the way for transformational systems that can meet Quadrennial Defense Review (QDR) requirements for equipment that is highly deployable, lethal, and survivable. As the 2001 QDR notes, “the full promise of transformation will be realized as we divest ourselves of legacy forces and they move off the stage and resources move into new concepts, capabilities, and organizations that maximize our war-fighting effectiveness and combat potential.” This means, longer term, the Army's transformational “system of systems”—the Future Combat System—will be the driving requirement in terms of future combat vehicle procurement.

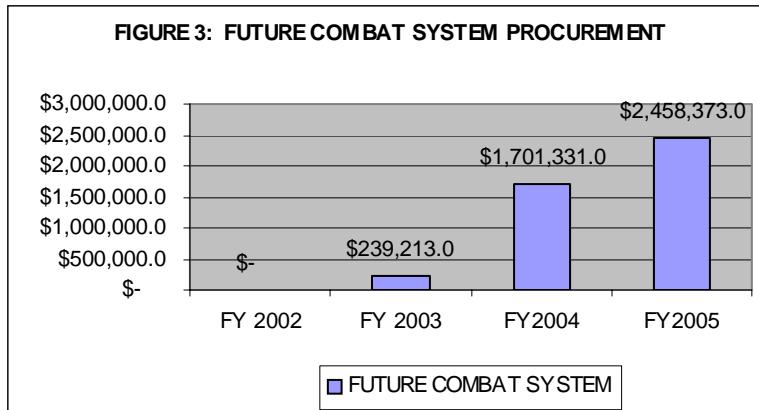
c) **Third, the Army's interim vehicle, Stryker, will dominate Army procurement spending on “tracked combat vehicles” in the 2004/2005 budget timeframe.** This is where the Army is putting procurement dollars in the tracked and wheeled vehicle arena in the near term, as illustrated in below.



Dollars in millions.

Source: Data extracted from the Department of Defense Budget for FY 2004-2005 (Procurement Programs-“P-1”)

d) Fourth, the place to find the future of land combat systems is in DoD's Research, Development, Test and Evaluation (RDT&E) budget. Again, looking at DoD's FY 2004-2005 budget, one finds significant growth in the Army's RDT&E budget, from \$7.1 billion in FY 2002 to \$9.5 billion in FY 2005—a 36 percent increase. The big growth item in the Army's RDT&E budget is the "Armored Systems Modernization" better known as the Army's Future Combat System. Its growth trend is shown in Figure 3.



Dollars in Thousands

Source: Data extracted from the Department of Defense Budget for FY 2004-2005 (RDT&E Programs-“R-1”)

The nearly \$2.5 billion being spent on Future Combat System RDT&E is an eye-opening sum when one considers that the Army's total tracked and tactical vehicle procurements taken together (i.e., actual hardware) will not be a great deal larger (\$2.8 billion). What does all this data mean to the land combat systems industry? It means that in the near term the industry's prime customer—the U.S. government—is reordering its priorities in favor of developing future systems in lieu of continued investment in today's legacy systems. To have a future in Land Combat Systems, a company will need to be a player in the “next big thing” for the Army—the Future Combat System.

Effects of Robotics on the Land Combat Systems Industry

Until just recently, the primary push for robotics in the United States has been in the manufacturing industry. The average U.S. citizen visualized robotic welding and parts manipulation stations on the assembly lines of the auto industry. Robotics applications tended to be focused on highly repetitive tasks. Workers in the U.S. have always felt that robotics may be a threat to their jobs, much the way they do today with computers and automation. This was not the case in Japan, and Japan is now considered the world leader in robotics. The pendulum is swinging the other way now in the U.S.

The U.S. military has been experimenting with inserting robotic technology into aerial platforms since World War I. Success was achieved in World War II with the ability to fly an unmanned B-17. For obvious reasons, unmanned aerial platforms are easier to deal with than unmanned land systems. The challenges of unmanned systems maneuvering across the surface of the earth is still a challenge today, but one that can now be managed.

Robotics technology would have been much further along in the U.S. than it is today had there been a push for it. We have moved from a culture that saw robotics as a threat to jobs, to one of a culture that sees robotics as a means for making our life easier and safer. Today the military has been making use of robotics very successfully. Recent efforts by our military in Afghanistan are a good example for the use of robotics. In Afghanistan robotics is being used for carrying heavy loads, identifying booby traps, performing countermine tasks, searching caves, tunnels and buildings. Robotic platforms carry many different sensors that when integrated into a single platform, provide our

soldiers with a powerful capability.

The event that caught the eye of the world, and particularly the U.S. congress, was the successful deployment of the Predator Unmanned Aerial Vehicle (UAV) by the CIA in Afghanistan. The Predator is a remote-controlled aircraft that the CIA used successfully to kill Al Qaeda leaders in Afghanistan and Yemen. Congress is providing \$131 million to buy 22 more Predators and \$129 million more for the much larger Global Hawk Surveillance drone. ^[4]

Robotics is now getting the push that is required to reach the real breakthroughs needed for fully autonomous vehicles within the next 10 to 15 years. Along with the additional dollars for the Predators and Global Hawks, the Senate defense panel recommended a \$75 million increase to the Future Combat Systems (FCS) program strictly for the use in unmanned systems. ^[5]

Congress is advocating that the military convert a sizeable portion of its fighting forces to robotic systems. They have encouraged the Defense Department to make one-third of all operational deep-strike aircraft to be unmanned within a decade. They also desire that one-third of all ground combat vehicles be unmanned or remotely operated within 15 years. This is a major shift from the past “unwritten” policy and doctrine that did not permit the “autonomous release” of lethal armaments. The CIA’s use of the Predator in Afghanistan and Yemen has opened the door for much broader use of unmanned weapons systems within the military

This Congressional direction and renewed DoD interest leads back to the issue of American culture. Americans don’t like casualties. We have become accustomed to fighting high-tech wars with minimal combat casualties. However, while it is clear that robotics can be used in ways that can minimize our soldier’s exposure to harm, our military’s doctrine will be slow to change. The military will need to slowly implement robotics into the force and build the required trust that the soldier will need to effectively employ robotics on the battlefield. Safety and reliability of robotic weapons systems will have to be addressed through better technology, experimentation, testing and training. The fear of an accidental firing that results in friendly fire casualties, civilian losses, collateral damage, loss of control, and reliability on the battlefield are all real issues that must be addressed. It now appears that traditional American aversion to robotics in the workplace is shifting in recognition that the benefits of robotics far out-weigh the risks of failure.

Current plans in FCS are to procure a range of unmanned systems: micro UAVs; larger higher - payload Tactical UAVs (such as the DARPA A160 Vertical Take Off and Landing (VTOL) platform); crawling insect-like robots; Unmanned Ground Sensors (UGS); 5-ton Mules; 16-ton unmanned Direct Fire platforms; and Scout Vehicles. The unmanned platform market is potentially going to make up a sizeable portion of the Land Combat System Industry in the next decade and beyond.

The current trend appears to be that of retrofitting existing systems for unmanned use. General Dynamics has a remotely controlled autonomous Stryker vehicle. ^[6] There are numerous other existing ground systems converted to unmanned systems such as the HMMWV, M60 Tank, M113s, M1, and more. Logistics vehicles such as large trucks are also being converted to unmanned vehicles as the military explores leader-follower concepts: unmanned logistics vehicles following manned systems in a supply train. There appears to a similar trend in airframes as well, such as proposals to make the F-16 and A-10 remotely piloted unmanned systems.

Retrofitting existing manned platforms to become unmanned platforms is a good way to reduce risk. It saves time and money and improves reliability. Starting with a platform that works in the intended environment, one only needs to add remote control or robotics capabilities. This retrofitting method will probably be used for some time to come, but it is only a matter of time before future systems will be designed from the start to be unmanned. The DARPA/Air Force/Boeing Unmanned Combat Aerial Vehicle (UCAV) program has already broken this ground. The Army’s Demo I and Demo II robotic platforms are another example.

Today’s systems have been designed to protect the human and provide human comforts. One of the high payoffs for robotic vehicles comes from the fact that they can be designed much differently

when the human is taken out of the picture. Platforms designed from the start to be unmanned can be much lighter, more robust and serve more missions. Suspension systems can be much different for unmanned platforms, which need not be concerned with which side is up. Removing the human factors from the design of unmanned systems opens the door to many new possibilities. More resources will be applied to functionality versus human comfort and protection.

The prospects of fighting in a nuclear/biological/chemical (NBC) environment today and into the future are cause for concern. The terrorist attacks on Sept 11, 2001 on U.S. soil have changed the rules of the game. Keeping American soldiers out of harm's way whenever practicable is true today and will be even more so into the future. Unmanned systems will play an ever more important role in how our military fights and wins our nation's wars. It is not clear how the LCS Industry will adjust itself to survive and thrive in this new environment.

Survivability of LCS platforms

The Army's transformation objective is a strategically and tactically mobile force that can "see first, understand first, act first, and finish decisively" as part of a joint force to achieve full-spectrum battlefield dominance. In a similar vein, the Marine Corps is developing the Advanced Amphibious Assault Vehicle (AAAV) and the MAGTF Expeditionary Family of Fighting Vehicles (MEFFV) to move greater numbers of Marines more rapidly onto objectives from the sea. Both organizations have ceased production and development, and for the most part upgrades, of their Abrams tank fleets. This shift to lighter, more agile forces empowered by information is one that radically affects the future of the armored portion of the land combat systems industry.

In order to properly resource the transformation of land systems, it is important to understand the rationale behind the abandonment of tanks and to develop an industrial base that can support it. Traditionally, the acquisition process has centered on heavily armored tanks and infantry fighting vehicles that were lethal and survivable in the close fight—so-called heavy forces. For close terrain, where tanks are vulnerable, the Army and Marines employed relatively inexpensive light forces, perhaps transported by helicopter, amphibious vehicle, or tactical airlift. Unfortunately, heavy forces were slow to deploy and difficult to support, while light forces were of limited use against an armored enemy in open terrain. The new network-centric concept seeks to leverage the American advantage in information technology and precision weaponry to cripple an enemy before making line-of-sight contact on the ground. The focus is not on the survivability and lethality of a single combat platform, but on the dominance of the total fighting force. Speed, agility, and information dominance are vital.

Doctrine and requirements are developing along with the technologies. The transformation to network-centric warfare calls for industry to be creative and innovative. In addition to making light vehicles that can fight successfully against tanks, the military needs industry to greatly reduce the logistics tail, to include ammunition consumption, spare parts, support soldiers, and consumables like batteries, water, fuel, and lubricants. It needs substantial improvements in system networking and distributed data processing. It needs cheap and effective unmanned ground and aerial vehicles. And, it needs all of it done at an affordable cost. The Army has contracted the Boeing Company to facilitate this system-of-systems optimization as the FCS Lead Systems Integrator, but the integration extends beyond materiel to doctrine and force structure choices.

The manned tactical and combat vehicle companies that we visited are willing to adapt, but only within what they perceive as their core competencies. They are system integrators, but integrators of *vehicle* systems, not fighting forces. They do not appear likely to be the source of the type of innovation that U.S. land forces envision. Despite their superficial resemblance to FCS, the European's system-of-systems programs like the British FRES and the French "Bubble" concept are relatively unambitious and will likely offer little to no technological advancement. A possible source of future system integration could be the information technology sector, which will have to understand the entire system-of-systems and will probably be the most expensive component on vehicle platforms. Robotics companies will likely become an ever more important part of land combat systems—these may or may

not develop from the current vehicle assemblers. Helicopters, attack aircraft, and UAVs must be integrated with ground systems, by a lead systems integrator, a military team, or a combination of the two.

For cases in which maneuver forces do enter into direct combat, they will need to survive by avoiding detection, avoiding hits, surviving hits, or killing the enemy first. The third of these, surviving hits, is the most difficult for lightly armored forces. Both explosive reactive armor and active protection systems offer promise in this area, but it does not seem likely that any C-130 transportable system will approach the ability of a tank or an IFV to take a hit from the front in the near future. In this respect, the nearly exclusive Army focus on Future Combat Systems is a risky course of action.

Transformation and the Services. In his seminal October 12, 1999 speech to the Association of the United States Army, Chief of Staff General Eric K. Shinseki called for future Army forces to have the “versatility and agility to transition from one point on [the full spectrum of operations] to another,”

unlike current light infantry or heavy armored forces.^[7] To create such forces, General Shinseki argued that the Army must aggressively reduce its deployed logistics tail, which today requires 90 percent of lift requirements, and also develop “smaller, lighter, more lethal, yet more reliable, fuel efficient, and more survivable” vehicles and weapons. He gave the Army a goal for strategic deployment of this force—a combat capable brigade in 96 hours, a division in 120 hours, and five divisions in 30 days. By doing so, Shinseki would give the “National Command Authority [president and Secretary of Defense] a genuine deterrent capability” able “to get to trouble spots faster than our adversaries can complicate a crisis.” If deterrence failed, then America would “prosecute war with an intensity that wins at least cost to us and our allies and sends clear messages for all future crises.”

General Shinseki called for the elimination of heavy forces “when technology permits” and for “an all wheeled vehicle fleet, where even the follow-on to today’s armored vehicles can come in at 50 percent to 70 percent less tonnage.” Each piece of the package would fit into a C-130 for tactical mobility. General Shinseki’s speech changed the world for the American land combat system industry, especially for those companies that had specialized in heavy, armored, tracked vehicles.

For their part, the Marines are developing a high-speed amphibious vehicle (the AAV) that will take most of the Marine Corps acquisition budget, but its tanks are also aging. The Marine Air-Ground Task Force (MAGTF) Expeditionary Family of Fighting Vehicles (MEFFV), is planned to replace both the M1A1 tanks and the infantry fighting vehicles. The heavy variant of the MEFFV is likely to be at least 50 percent heavier than the Army’s Future Combat Systems vehicles.^[8] The MEFFV is twenty years from fielding, which could allow the USMC to observe the Army’s “objective force” develop.

Considerations of Depot-level Maintenance

The toppling of the Berlin wall and the collapse of Soviet communism changed the mindset and budget of the United States Department of Defense (DoD). The military spending spree through the 1980s was over, the cold war era equipment was aging, and the U.S. was looking for the infamous ‘peace dividend.’ These events, along with other contributing factors, led DoD to conduct seven different strategic reviews (force structure studies) and four rounds of Base Realignment And Closure (BRAC) studies hoping to create savings, particularly in the area of depot level maintenance.

Depot-level maintenance is defined as the ability to rebuild and overhaul major end items of equipment.^[9] This is the highest level of maintenance within the maintenance system and uses industrial-type production lines. This type of maintenance also requires sophisticated skills, tools, test equipment, and facilities. Maintaining this type of capability is synonymous with maintaining readiness, you can’t have one without the other.

Depot level maintenance is also big business within DoD and the private sector, and will become even more important in the future as orders of new weapons systems decline.^[10] Currently there are 21 DoD government-owned facilities within the continental U.S. vying for an estimated 40 billion dollars

in annual resources. Additionally, defense maintenance employs nearly 700,000 of the military active and reserve component and DoD civilian personnel. Supported weapons systems include approximately 300 ships, 5,000 aircraft, and helicopters, 1,000 strategic missiles, and 350,000 ground combat and tactical vehicles. [11] What are the options to the federal government to maintain high quality products at a reasonable cost?

Title 10 of the United States Code governs the conduct of depot level maintenance. It requires the government to maintain the capability to conduct depot level maintenance.

There are three basic options to maintaining depot level maintenance; *public* – retain the capability in the government.

The acquisition process has a significant effect on DoD's ability or inability to conduct competition.

There are 21 government-owned/government-operated depot-level maintenance activities (DMAs).

The aging depot workforce, coupled with depot downsizing, compounds the problem of maintaining the capability.

Privatization is clearly a very viable option for depot level maintenance. However, Congressional representatives have the ability to influence government and DoD contracts. Strong Congressional support for the depots, combined with the 50-50 rule adds credibility to the private industry claim that the process of awarding a contract is an uneven playing field.

Competition is an important factor in keeping maintenance costs down. Privatizing all the depots may reduce the competition, raising the concern that privatization would escalate costs, causing the 'outsourced' maintenance to be unaffordable. This is particularly worrisome if the Land Combat System industry is reduced to only one competitor or lead systems integrator per sector.

A second concern with privatization is whether the private companies and their depot capabilities will 'be there' when the system requires rebuilding. DoD has a habit of extending the life of weapons systems well beyond its original life cycle. Legacy systems are increasingly expensive to maintain and a rebuild must be considered as part of the acquisition process. [14]

Partnerships are a third option for resolving the depot maintenance dilemma. Partnerships include:

The world has changed in the last decade but the requirement of Title 10 to *maintain the public responsibility* remains.

CONCLUSIONS:

The overall health of the land combat systems industry is mixed: some elements of the industry are in good condition, while others are clearly nervous about their future. Industry consolidation has continued through the course of our study, and we expect the trend toward mergers and acquisitions to continue. Companies which have not managed diversification well, or which continue to rely solely upon defense contracts, will probably struggle to maintain viability, especially as defense budgets continue to decline. One U.S. firm has made great strides in penetrating the European market by acquiring European companies.

All of the companies visited are concerned about continued decreases in demand for land combat systems and the overall decline in funding for these systems. With the virtual cessation in purchases of main battle tanks, capability upgrades and after-sales support of the vehicles have become more important. The decline in production has exacerbated the industry-wide problem of excess capacity, thus increasing the costs of fielded systems. How much capacity is enough? Should governments pay for idle capacity to keep the businesses afloat? Meanwhile, the competition for sales of infantry fighting vehicles remains intense, with a large number of very similar vehicles available from nearly every European country. The U.S. Army terminated a large number of programs to fund the fielding of the Stryker brigades (as an interim capability) and the development of the Future Combat Systems. The current funding levels appear to place the entire U.S. LCS industry at increased risk.

Despite all the discussion of transformation, we find the LCS industry is still focused on building tactical vehicles and weapons platforms, and in our observation, only one traditional U.S. armored vehicle firm is thinking hard about the problem of how to transform. There is not enough focus on integration of systems and C4ISR. Further, there seems to be little real industry interest in pursuing

developing technologies needed for Future Combat Systems, such as network-centric and information technologies, robotics, and hybrid power systems. The real focus, as mentioned above, remains on platforms.

While the European nations are watching the Army's FCS program carefully, and some of who have expressed general plans for "similar" capabilities, none we visited sincerely expect to be able to field the advanced network-centric FCS capability. This transformational program will serve to increase the technological gap between the United States and its allies. This widening gap will continue to create significant challenges for American forces operating in coalitions with nations without these capabilities. Further assessment is required in order to consider the risks associated with the pursuit of the FCS concept. The risks associated with future battlefield threats and conditions, technological advances, and so forth, must be carefully reassessed, especially in an international climate that will continue to require U.S. military intervention.

The survivability of the interim and objective force's lightweight vehicles (Stryker and FCS) is heavily dependent on information dominance ("...trading armor for information"). The ability to achieve real full-spectrum information dominance and lethality cannot be guaranteed, especially within the aggressive deployment schedule of FCS, hence the continued need for continually updated legacy systems. It is our observation that recent operations in Iraq point toward a continuing role for the main battle tank on the battlefield well into the future. There's a place for legacy systems: The objective force's conceptual platforms must be balanced with proven legacy platforms to ensure the technological risk associated with FCS is minimized. Therefore, the Army needs to ensure adequate resources to maintain some portion of the Abrams fleet as part of the objective force. We believe the Abrams tank will be the B-52 of the LCS industry, continuing to operate long after its intended design life.

The selection of the Boeing Company as lead systems integrator for the U.S. Army's Future Combat Systems is significant. A traditional aerospace firm with no experience in land combat systems, Boeing will now be responsible for the overall integration of numerous individual programs into a deliverable "system of systems" capability. Although this selection is not the very first example of the LSI concept, several concerns remain. How much decision-making authority does Boeing really have? Does this process injudiciously circumvent competition at the system, subsystem, and component levels? Can the proprietary technology and design issues be overcome? Many companies we visited stated they want to become known as system integrators rather than merely as product manufacturers. The LSI concept shows that this industry is no longer just about bending metal, but requires a new way of thinking to remain viable.

We conclude that the land combat systems industry remains vital to national security. The end products, ranging from main battle tanks to small wheeled tactical vehicles, provide tremendous military capability that will continue to be required well into the foreseeable future. This industry is currently undergoing significant change, and it remains to be seen whether the planned transformation of the U.S. Army will be successful.

Bibliography

“AM General Corporation.” On-line. Form 10-K, Fiscal year ending Oct 31 2001. <http://www.sec.gov/archives/edgar/data/>

“Army Considering International Involvement in Future Combat Systems.” *Inside the Pentagon* (March 14, 2003).

Army News Service. “Robot finds booby traps in Afghanistan.” March 5, 2003.

Baumgardner, Neil. “GD Looking at 105mm Howitzer, Robotics For Stryker.” *C4I News*, Potomac, January 9, 2003.

Baumgardner, Neil. “Oshkosh, Stewart& Stevenson Preparing to Battle For Future Truck Orders.” *Defense Daily*: Potomac; Dec 19 2001.

Bolton, Claude M., Jr. (Asst. Sec. Army for Acquisition, Logistics, and Technology) *Statement before the House Armed Services Subcommittees on Military Procurements and Military Research and Development*. March 6, 2002. Online at <http://commdocs.house.gov>.

Bowling, Kenneth B. *Military Readiness and Outsourcing Depot Repair*, U.S. Air Force Logistics Management Agency, Winter 2000.

Brewer, Trixie. *Organic Depot Maintenance Re-Capitalization*, Chief, Enterprise Systems Opportunities Branch, Galaxy Scientific Corporation.

Cahlink, George. “Army Starts Talks on Privatizing Arsenal.” *Federal Times*, Volume 36, Issue 3, 21 February 2000.

Cahlink, George. “Partners for Life.” *Government Executive*, Volume 33, Issue 13, October 2001.

Cahlink, George. “No Defense.” *Government Executive*, Volume 33, Issue 15, December 2001.

Cahlink, George. “Face Lift for Air Force Depots.” *Government Executive*, Volume 34, Issue 15, November 2002.

Chao, Pierre A. “The Structure and Dynamics of the Defense Industry.” (Credit Suisse First Boston, Global Aerospace/Defense Group, Feb. 4, 2003).

Coburn, General John G. *Congressional Testimony on Depot Maintenance and Repair*, March 23, 2001.

Cushman, John H., Jr. *The Late Edition*. New York, December 1, 2002.

Dembeck, Chet. “Army Leaders Look to Private Sector To Revitalize Underused Depots.” *Army Times*, November 4, 2002.

Dembeck, Chet. “Army Privatization Plan ‘Unacceptable’ Lawmakers Say.” *Federal Times*, 28 October 2002.

Dembeck, Chet. “Army Leaders Look to Private Sector To Revitalize Underused Depots.” *Army Times*, November 4, 2002.

Department of Defense, Annual Industrial Capabilities Report to Congress (Washington, D.C.: February 2003).
Department of Defense Budget, Fiscal Years 2004/2005, (Washington, D.C.: Department of Defense, February 2003).

Department of Defense, Office of the Deputy Under Secretary of Defense (Logistics and Materiel Readiness). “Maintenance Policy, Programs, and Resources.” *Fact Book, 2002*.

Erwin, Sandra I. “Array of Army Hybrid-drive Vehicles Expanding Steadily.” *National Defense Magazine*, www.nationaldefensemagazine.org/article.cfm?Id=457, 24 February 2003.

Field Manual 3-100.21, *Contractors on the Battlefield*, United States Army, 3 January 2003.

“General Dynamics.” On-line. <http://www.sec.gov/archives/edgar/data/> .

Hanlon, Edward, Jr. (Commanding General, Marine Corps Combat Development Command). *Statement before the House Armed Services Subcommittees on Military Procurements and Military Research and Development*. April 11, 2002. Online at <http://commdocs.house.gov>.

H.A.S.C. No. 107-37, *United States Defense Industrial Base: Hearing Before the Military Procurement Subcommittee of the Committee on Armed Services, House of Representatives, One Hundred Seventh Congress, Second Session*. Hearing held March 19, 2002. Online at <http://commdocs.house.gov>.

Held, Bruce, Kenneth Horn, Michael Hays, Christopher Hawks, Paul Stienbury, Christopher Pernin, Jamison Medby, and Jeff Brown. *Seeking Nontraditional Approaches to Collaborating and Partnering with Industry*. Santa Monica: RAND Arroyo Center, 2002.

House Committee on Armed Service. *Testimony of DUSD for Industrial Policy*, 19 March 2002 U.S. Senate Subcommittee on Procurement, Washington D.C.

Howard, Michael. *War in European History*. Oxford: Oxford Univ. Press, 1976.

Kaminski, Paul G. "Competition Between Public Sector (Organic) Maintenance Depots and Private Sector Commercial Firms." Memorandum dated May 2, 1997.

Keeter, Hunter. "Army Launches \$12 Million Outsourcing Review." *Defense Daily*, Volume 201, Issue 27, February 11, 1999.

Kennedy, Harold. "Who Will Build U.S. Army's New Medium -Weight Truck?" *National Defense Magazine*, January 2002.

Lambeth, Benjamin S. *Technology Trends in Air Warfare*. Santa Monica, CA: RAND, 1996.

Nagle, James F. *A History of Government Contracting*. Washington D.C.: The George Washington University, 1992.

O'Hanlon, Michael E. *Technological Change and the Future of Warfare*. Washington, DC: Brookings Institute, 2000.

"Oshkosh Truck Corporation." Form 10-K, Fiscal year ending 30 Sept 2002. <http://www.sec.gov/archives/edgar/data/>

Phinney, David. "Contractors fill combat niche." *Defense News*, 4 February 2003.

Pierce, George M. II. "Robotics: Military Applications for Special Operations Forces." Air Command and Staff College, Air University Press.

Quadrennial Defense Review Report. Washington, D.C.: Department of Defense, 2001.

Read, Robert. Office of Deputy Under Secretary of Defense for Industrial Policy. "Ground Combat Systems Defense Industrial Base." Briefing given to Land Combat Systems Industry Study seminar on January 30, 2003.

Riggs, Johnny M. "A Holistic Approach to Army Transformation." Online. Internet. 10 March 2003.

Riggs, John M. (Director, Objective Force Task Force, United States Army). *Statement before the House Armed Services Subcommittees on Military Procurements and Military Research and Development*. April 11, 2002. Online at <http://commdocs.house.gov>.

Scales, Robert H. *Future Warfare*. Carlisle Barracks, PA: Strategic Studies Inst., 2000.

Shrader, Dr. Charles R. "Contractor on the Battlefield." The Institute for Land Warfare – Landpower Essay Series, Association of the Untied States Army, No. 99-6, May 1999.

Sherman, Jason. "The Depot Dilemma." *Armed Forces Journal International*, October 1997.

Shinseki, General Eric K. Address to the Eisenhower Luncheon, October 12, 1999. Online. 10 March 2003. <http://www.army.mil/leaders/csa/speeches/991012.htm>.

Sherman, Jason. "Out of the Loop." *Armed Forces Journal International*, Vol. 137, Issue 12, July 2000.

"Single Stock Fund Campaign Plan", <http://www.army.mil/SSF/Campaignplan>, 22 February 2003.

"United Defense Industries Inc". On-line, Form 10-K/A year ending Dec 31, 2000. <http://www.sec.gov/archives/edgar/data/>

United States Army White Paper: Concepts for the Objective Force. Online. Internet. 10 March 2003.

United States Army. *TRADOC Pamphlet 525-3-90/O&O: Objective Force Operational and Organizational Plan for Maneuver Unit of Action*, 22 July 2002, U.S. Army Training and Doctrine Command, Fort Monroe, VA.

United States Army. *Operational Requirements for the Future Combat Systems*, January 2003, Unit of Action Maneuver Battle Lab, Fort Knox, KY.

United States General Accounting Office, *Defense Depot Maintenance: DoD Shifting More Workload for New Weapons Systems*

United States General Accounting Office, *Defense Depot Maintenance: Use of Public Private Partnering Arrangements (GAC)*

United States General Accounting Office, *Depot Maintenance: Future Year Estimate of Public and Private Workloads are Likely to Increase*

United States General Accounting Office, Commercial Activities Panel, *Improving the sourcing Decisions of the Government, Final Report*, April 2002.

United States General Accounting Office, Defense Depot Maintenance, *Uncertainties and Challenges DoD Faces in Restructuring*

United States General Accounting Office, Performance and Accountability Series, *Major Management Challenges and Programs*

The Value Line Investment Survey, (Value Line Publishing, New York: Value Line Publishing, Inc., December 27, 2002 edition).

Withers, John R. *Contracting for Depot-level Maintenance*, Army Logistics Management College's Logistics Executive Development Course, Fort Lee, Virginia. Jan/Feb 2000.

END NOTES

[1] Bob Read, Office of Deputy Under Secretary of Defense for Industrial Policy, Ground Combat Systems Defense Industrial Base. Briefing given on January 30, 2003.

[2] George M. Pierce II. "Robotics: Military Applications for Special Operations Forces." Air Command and Staff College, Air University.

[3] Army News Service, March 5, 2003, "Robot finds Booby Traps in Afghanistan."

[4] John H. Cushman, Jr. *The Late Edition*. New York: December 1, 2002.

[5] Jason Sherman. "Out of the Loop." *Armed Forces Journal International*, Jul 2000, Vol. 137, Issue 12,

[6] Neil Baumgardner. "GD Looking at 105mm Howitzer, Robotics For Stryker." *C4I News*; Potomac; January 9, 2003.

[7] General Eric K. Shinseki. *Address to the Eisenhower Luncheon*, October 12, 1999. Online. Internet. Accessed March 10, 2003. <http://www.army.mil/leaders/csa/speeches/991012.htm>.

[8] MEFFV variants are projected to be 10 tons and 30 tons, while the C-130 lift requirement limits FCS vehicles to about 16 tons.

[9] The editor does not differentiate between rebuild, remanufacture, recapitalization, modernization, etc...there are technical, subtle differences, but that is outside the scope of this essay.

[10] Jason Sherman. "The Depot Dilemma." *Armed Forces Journal International*, October 1997.

[11] Department of Defense, Office of the Deputy Undersecretary of Defense (Logistics and Material Readiness). *Maintenance Policy, Programs, and Resources Fact Book 2002*.

[12] John R. Withers. *Contracting for Depot-level Maintenance*, Army Logistics Management College's Logistics Executive Development Course, Fort Lee, Jan/Feb 2000.

[13] Paul G. Kaminski. Undersecretary of Defense (Acquisition and Technology) Memorandum, "Competition Between Public Sector (Organic) Maintenance Depots and Private Sector Commercial Firms," May 2, 1997.

[14] General John G. Coburn, Commander, U.S. Army Materiel Command. *Congressional Testimony on Depot Maintenance and Repair*, March 23, 2001.

[15] Chet Dembeck. "Army Leaders Look to Private Sector To Revitalize Underused Depots," *Army Times*, November 4, 2002.